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In Bulletin 33 of the U.S. Division of Entomology, Mr. L. O. Howard presents a valuable compilation concerning American Legislation Against Injurious Insects.

EMBRYOLOGY.[1]

Conjugation of the Brandling.—Of the many kinds of earthworms common in the Eastern United States one of the best known is the prettily colored but offensive-smelling species often called the striped worm from its conspicuous cross bands of red-brown and yellow, but known to the specialist at present as *Allolobophora fœtida.* It abounds in decaying vegetable matter especially in compost and manure heaps where it lies a few inches beneath the surface and may be readily captured though quick and active in its movements. In some regions it is regarded by the youthful angler as especially attractive bait for trout and as bait it has been used ever since the days of Isaac Walton who refers to it repeatedly in the Complete Angler by a name too characteristic to be lost from our vocabulary—the brandling. Thus in speaking of bait for the perch he says—" and of worms the dunghill worm called the brandling I take to be the best, being well scoured in moss or fennel."

It is well known that earthworms, though they are hermaphrodites yet interchange sexual products in a remarkable process of conjugation. Our knowledge of this process, is however, confined to the accounts of two naturalists who studied the large European earthworm *Lumbricus terrestris.* W. Hoffmeister, whose work on earthworms published in Brunswick in 1845 was the pioneer in a field that was later so diligently tilled by French and of late by English specialists, observed the worms as they came out on the surface of the ground in the night-time and obtained a pretty good idea of the main phenomena of conjugation.

His account is in the main as follows: " The old worms leave their holes first, the younger ones only when it is quite dark. They protrude their bodies with great caution and very slowly, after resting a while they feel about with the anterior end of the body till they reach a neighbors's hole or come upon another worm. They now crawl along

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[1] Edited by E. A. Andrews, Baltimore, Md., to whom abstracts, reviews and preliminary notes may be sent.

against and carefully examine one another. If the worm that is found is not mature or even if it is smaller than the seeker, greeting does not last long and the worm continues his search in some other direction till he succeeds in finding some other individual like himself . . . .
. . . . He generally finds one waiting or else entices one from its hole by thrusting his head into it. They undulate against one another; now one now the other drawing back is always followed by his companion. The movements soon become more active; they strike one another with their heads.

At length they both lie still with the ventral surfaces near together. The body begins to undulate, especially at the girdle and within a few minutes the sucking action of the girdle comes into play to establish a more firm union of the two animals. The side parts of the girdle that bear the sucking disks are spread out in wing-like expansions while the ventral part is much drawn in. In this way a sort of tube is formed and in this the other individual is enclosed.

The mutual adjustment of one to the other becomes more and more close and accurate while the undulations of the transverse muscles and of the girdle constantly increase. Meanwhile mucous flows copiously from the dorsal pores and from the girdle. Usually a lot of young worms now assemble and greedily suck up the mucous.

The pair lie motionless for a good half hour before the seminal fluid could be seen flowing out . . . .

Once I watched for a pair the day after conjugation, in vain, but the following day I found one of the two in conjugation again. Conjugation seems to be repeated so often that one may imagine a separate fertilization for each egg.

In the above account all that refers to the actual transfer of sperm has been omitted as it contains many errors that have been corrected by our only reliable authority on this problem, Ewald Hering,[1] who in 1856 as a medical student in Leipzig made so careful a study of the reproductive organs of the earthworm that many years elapsed before his discoveries were rediscovered and introduced into text books in place of the erroneous views long lingering there.

His account of the conjugation of earthworms is all the knowledge we have of the process, at present, and is here translated in full to make intelligible the facts that we have to add in regard to conjugation in the brandling.

" When conjugating the worms lie in opposite directions with their ventral sides applied to one another. By drawing in the ventral side each hollows out the girdle and the neighboring rings into a boat-shaped depression. The other worm lies in this excavation. There is then a copious secretion of mucous that gradually hardens on the surface and encloses both worms is a common envelope. The union becomes closer and closer, especially so in the regions of the girdle and of the male openings.

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[1] Zeit. f. wiss. Zool., VIII, 1856.

The ventral elevations of the girdle always lie opposite to the 9th, 10th and 11th rings of the other worm while the ventral elevations about the male openings lie opposite to the 26th ring.

The elevations of the girdle begin to contract rhythmically. Anterior to the girdle the region between the upper and lower setæ on each side swells up as a longitudinal elevation bounded by two longitudinal grooves. As the worms lie on one side this can be seen only on the other, upturned side. This elevation forms gradually from behind forward as far as the 15th ring when it terminates in the glandular swelling about the male opening. In a live worm the position of the grooves bounding the above elevation is indicated by two more or less darkly pigmented parallel lines on each side from the 15th ring to the girdle (Hoffmeister erroneously regarded these as canals). When a worm is thrown into spirit it generally forms in its violent contractions both the longitudinal elevations and the boat-like excavation of the girdle.

Since the ventral surface is flattened out or even made concave during conjugation the ridges of both worms lie pretty close together and the lower or less essential furrow is concealed from observation. The upper furrow, however, is evident as a longitudinal groove along which we may see waves of muscular contraction passing from before backward. This contraction consists essentially in a change in the furrow and its rims. The rims draw together to form a pit in the 15th ring which then passes back to the girdle, like the trough of a wave. In one minute about fourteen such pits may be seen to form and pass back.

The ejection of sperm takes place only after an hour or more from the beginning of conjugation. We see a small drop ooze out of the slit in the elevation of the 15th ring and enter the longitudinal furrow where it looks like a white rod about as long as a ring is wide. This drop of sperm is taken up by the pit above described and led backward. When it has proceeded abouts its own length from the opening a new drop is poured out and so on. The ejection of sperm thus takes place with rhythmic interruptions and we see passing back in the furrow a row of small white rods separated by intervals equal to their own length. As the rods as well as the intervals between them just equal the length of a ring, every other ring will have a drop of sperm in its furrow at any given moment. The sperm thus flows from the 15th ring to the girdle outside the animals, covered only by a layer of mucous. We may calculate the time taken as about 80‴.

The girdle now becomes especially active. Its muscular elevations on the sides and at each end contract rhythmically about fifty-five times a minute to form shallow depressions which advance in a wave-like manner. The lateral depressions move downward and the end depressions toward the middle of the girdle ridge so that the sperm that has been poured out and accumulated between the worms under the girdle is concentrated, more and more, about the openings of the seminal receptacles, which lie opposite to the swollen part of the girdle. The same object is accomplished also by a second rhythmic motion that occurs about twice a minute; the lateral part of the girdle alternately presses against and lifts up from the other animal and so drives the sperm towards the openings of the seminal receptacles. There is no doubt that the sperm is taken into the seminal receptacles; their openings lie free under the mucous envelope and the sperm may be seen collecting about them. Perhaps the taking in is brought about by some sucking action of the receptacles. Though the ridge on the girdle continues to collect the sperm about the openings it cannot press it in as it does not cover them. G. Meissner mentioned accessory organs concerned in introducing sperm and eggs into these narrow openings, but as yet I have found none.

When the ejection of sperm is finished the longitudinal swelling and furrow slowly disappear in the direction opposite to that in which they appeared. The contractions of the girdle yet continue for some time till the sperm has so far disappeared that only a small drop remains about each opening of the seminal receptacles. When the conjugation has taken a normal course these white drops are found on both worms and on both sides of each. I often examined them microscopically and never found any eggs though they probably would have been present if, as Meissner supposed, they are taken into the receptacles along with the sperm.

At length the worms separate from one another by a powerful wrench for which the tail ends that still remain in the ground serve as points of resistance. If we cut off both tails at once the worms often remain united for hours. If thrown into spirit they die without separating.

The entire act of conjugation lasts two to three hours and may be easily observed under the lens since the worms are shy only in the early stages while when an intimate union has taken place we may use a brilliant light and even lightly touch without disturbing them.

PLATE XXXIII.

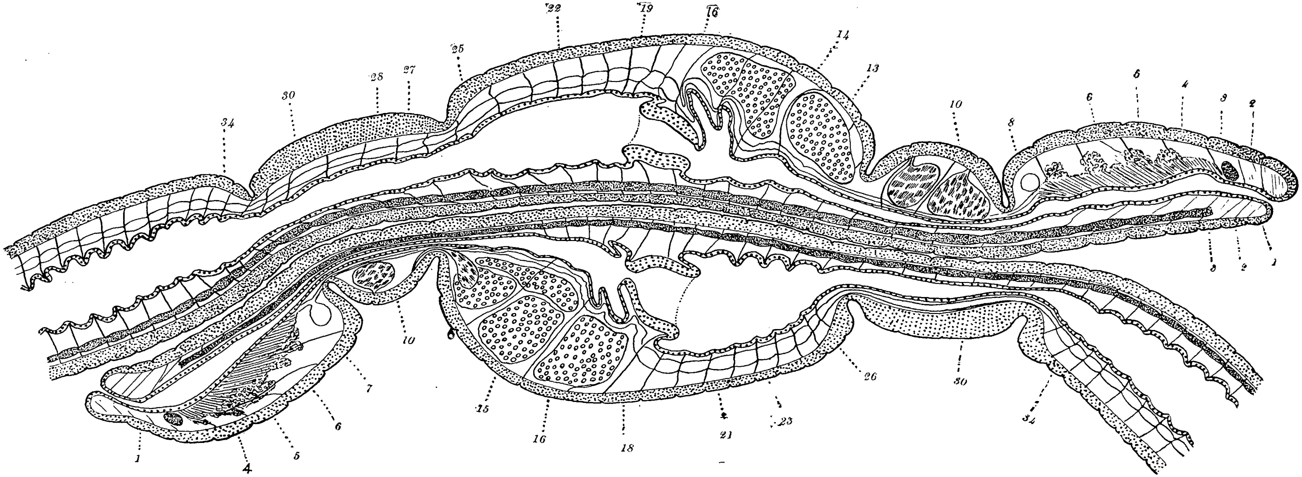

FIG. 2.

Andrews on Allolobophora.

PLATE XXXIV.

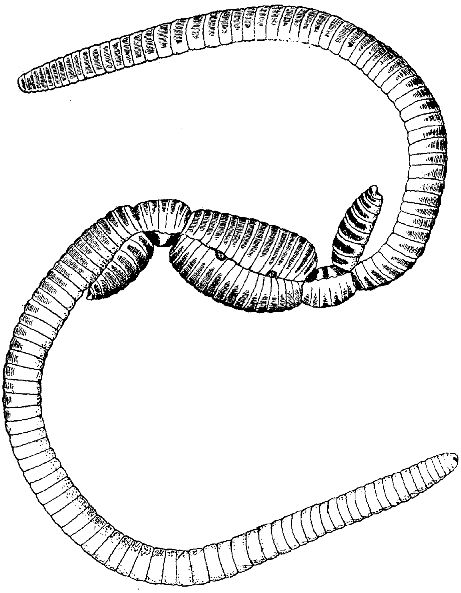

FIG. 1.

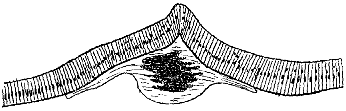

FIG. 4.

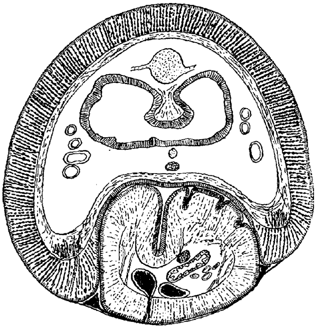

FIG. 5

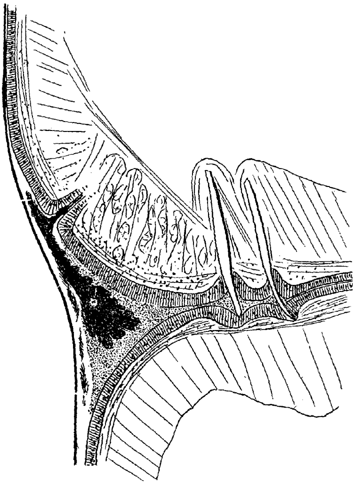

FIG. 6.

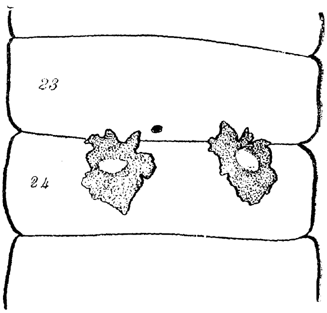

FIG. 3.

Andrews on Allolobophora.

The formation of the grooves and the ejection of sperm do not always take place simultaneously in both worms. They may also be of considerably different dimensions and yet accomplish conjugation since they are so changable in form. As a rule, however, both worms act in every respect alike.

As it seems scarcely credible that the sperm should not spread out on the moist surface of the body one might at first suppose that it flowed back in a canal covered only by the transparent epidermis, yet no such canal is to be found nor any opening at the girdle. Moreover the seminal ducts open directly to the exterior and in handling a long worm, I once saw issue a white drop of what proved under the microscope to be sperm.

After conjugation a small flat, club-shaped process is found on each side of the worms. This so-called penis is about 1‴ long and is generally in the region of the 26th ring, seldom at the girdle. It generally lies in the region of the ventral setæ, sometimes on and sometimes between rings. It is sometimes duplicated and sometimes absent upon one or both sides. It gradually becomes harder though at first soft; it is a hyaline mass with a droplet of sperm imbedded in its free end. In my opinion it is made of hardened mucous. Before conjugation it is absent; if we separate conjugating worms before ejaculation it is soft and contains no sperm; it is demonstrably a product of conjugation. When formed in the region of the 26th ring opposite the male opening it receives sperm from the other individual and in the few cases in which it is on the girdle it receives sperm from the worm on which it is found. In the exceptional cases in which it lies on other regions of the body it contains no sperm.

It seems superfluous to describe all the varieties of form, number and position of such an unessential structure."

Many features of the above remarkable interchange of sperm may be readily observed in wet nights in the Spring and Autumn in the public parks of Baltimore where this large earthworm, *Lumbricus terrestris* has been introduced.

In the case of the smaller brandling, direct observation is precluded by the fact that the worms do not come to the surface to conjugate but lie closely appressed and bent some inches beneath the surface of the wet dung heaps they abound in. When disturbed they slowly separate. The following facts relative to their conjugation are hence confined to observations upon preserved material.

At Byrn Mawr, Penn. in May, 1892 and in Baltimore in May, 1895 attempts were made to harden the worm in pairs by the use of Perenyi's liquid, picric acid, chromic acid and Merkel's liquid but the worms separated in hardening; it was found, however, that when thrown into hot corrosive sublimate or even into boiling water the animals remain in a very natural position. This is due to the fact they are enveloped, especially in the region of the girdle, by a secretion that is coagulated by heat while the worms themselves are so quickly killed that they do not contract enough to change shape or to tear themselves apart. It is thus possible to obtain preserved pairs such as indicated in figure 11 that very accurately indicate the appearance of the conjugating worms when alive.

Even the large Lumbricus may be well preserved in pairs by plunging into actively boiling water and then hardening in alcohol.

From figure 11 it will be seen that a pair of conjugating brandlings lie in a somewhat S shaped figure with the heads in opposite directions and the ventral sides turned toward one another anteriorly though posteriorly each may have it ventral side in the normal position, downward. Each may twist so that its anterior part lies on the side, the right or left in both worms. It is noticeable that at two regions the worms appear constricted as if threads had been drawn about them but in reality it is only the firm envelope of mucous which binds them together. These two regions are separated by a long expanded region on the side of which may be seen the swelling about the male opening. Each constricted region is made up by the light colored girdle on one worm and the small dark colored region near the head of the other, a region of three rings that we will find subsequently are nearly enclosed by the girdle. The most anterior part of each worm may be free and is then immediately followed by the short region so very firmly clasped by and attached to the girdle. This free tip of the body contains seven rings in each worm. The following part that fits into the girdle contain three or four rings. The expanded region between this and the following girdle contains fifteen or sixteen rings and the girdle itself six or seven. Posterior to the girdle the animals may be nearly or quite free from one another so that the extend of the closely united region when the seven anterior rings are free, may be only twenty-four to twenty-seven rings of the entire one hundred, approximately, that make up the worm. The applied areas do not fit together exactly ring to ring and though they begin and end at the same distance from the head in each worm a fixed point, such as the male openings in the fifteenth ring, is not exactly opposite the same ring in each case. Approximately the male opening on the fifteenth ring of one is opposite the twenty-first ring of the other worm whereas we would expect it to be diagrammetically opposite the twenty-fifth if the seventh ring of one is opposite the thirty-third of the other.

(*To be continued.*)

PSYCHOLOGY.[1]

Recent Work in Hypnotism.—With the June number the "Revue de l'Hypnotisme" completed its ninth volume and in turning over its pages I find several articles that are of more than merely technical interest.

Liébeault of Nancy contributes two articles on the psychology of normal sleep and its relations to hypnotic sleep and waking life. The essential characteristic of waking life is the activity of attention and will; in sleep both faculties become quiescent; in hypnosis we find an anomalous "polarisation" of attention, it being riveted on the idea of sleep on the one hand, whereby actual sleep is induced, and on the personality of the hypnotizer on the other. Will is quiescent, and thus the patient becomes amenable to suggestion. Violent passions, "fascination," aboulia, and all other states in which will power is weakened, are to be regarded as akin to sleep.

Prof. Matias-Duval outlines a histological theory of sleep suggested by the Golgi-Cajal doctrines. Admitting that the ultimate nervous elements are functionally related, not by actual physical continuity, but by mere contiguity, it is natural to suppose that the transmission of nervous activity would be facilitated by approximation of the terminal filaments. It is not improbable that they may be capable of amœba-like extension such as has been observed by Wiedersheim in the brain of *Leptodora hyalina.* It is possible that a paralysis of these terminal filaments may be brought about by the absence of oxygen and excess of carbonic acid; the transmission of nervous activity would thus be impeded and sleep supervene.

Dr. Raphael Dubois contributes a paper on the physiological conditions of hibernation in the marmot. He has been unable to find traces in the blood of the hibernating animals of toxalbumens, toxines or other somniferous agents, but has found an excess of carbonic acid which he ascribes in part to the depression of circulation, respiration

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[1] This department is edited by Dr. Wm. Romaine Newbold, University of Pennsylvania.